

What is claimed is:

1. A heat treatment apparatus comprising:
 - a processing vessel defining a processing chamber for processing an object to be processed therein;
 - a heater that heats the object;
 - a thermal sensor arranged in the processing chamber;
 - a temperature estimator that estimates a temperature of the object based on a detection signal from the thermal sensor;
 - a temperature calibrator that corrects the temperature of the object estimated by the temperature estimator thereby to obtain a calibrated temperature of the object; and
 - a controller that controls an operation of the heater based on the calibrated temperature of the object.
2. The heat treatment apparatus according to claim 1, wherein the temperature calibrator includes:
 - an offset table storing an offset value representing a difference between the temperature of the object estimated by the temperature estimator and a true temperature of the object; and
 - an offset value adding part that adds or subtracts the offset value to or from the temperature estimated by the temperature estimator.
3. The heat treatment apparatus according to claim 1, wherein:
 - the processing chamber has a plurality of zones;
 - the heater has a plurality of heater elements each disposed in each of the zones;
 - the thermal sensor has a plurality of sensor elements each disposed in each of the zones;
 - the temperature estimator estimates the temperature of each of the objects positioned in each of the zones;
 - the temperature-calibrator corrects the temperature of each of the objects positioned in each of the zones; and

the controller controls an operation of each of the heater elements in each of the zones based on a calibrated temperature of each of the objects corrected by the temperature calibrator.

4. The heat treatment apparatus according to claim 1, wherein the heater is arranged outside the processing vessel, said apparatus further includes a second thermal sensor which is arranged, outside the processing vessel, between the heater and the processing vessel; and

wherein the temperature estimator estimates the temperature of the object based on respective detection signals from the first thermal sensor and the second thermal sensor.

5. A heat treatment apparatus comprising:

a processing vessel defining a processing chamber for processing an object to be processed therein;

a heater that heats the object;

a thermal sensor arranged in the processing chamber;

a temperature estimator that estimates a temperature of the object at an estimation time-point based on a detection signal from the thermal sensor, the temperature estimator estimating the temperature of the object at the estimation time-point based on detection signals from the thermal sensor at several time-points preceding the estimation time-point;

a temperature calibrator that corrects the temperature of the object estimated by the temperature estimator thereby to obtain a calibrated temperature of the object; and

a controller that controls an operation of the heater based on the calibrated temperature of the object.

6. The heat treatment apparatus according to claim 5, wherein the estimation time-point is a present point in time.

7. The heat treatment apparatus according to claim 5, wherein the estimation time-point is a time of point in the

future of a present point in time.

8. The heat treatment apparatus according to claim 5, wherein the temperature estimator estimates the temperature of the object in accordance with a calculation program based on ARX model.

9. A heat treatment apparatus comprising:

- a processing vessel defining a processing chamber for processing an object to be processed therein;

- a heater that heats the object;

- a thermal sensor arranged in the processing chamber;

- a temperature estimator that estimates a temperature of the object based on a detection signal from the thermal sensor;

- a temperature calibrator that corrects the temperature of the object estimated by the temperature estimator thereby to obtain a calibrated temperature of the object, the temperature calibrator having an offset table storing an offset value representing a difference between the temperature of the object estimated by the temperature estimator and a true temperature of the object, and an offset value adding part that adds or subtracts the offset value to or from the temperature estimated by the temperature estimator;

- a controller that controls an operation of the heater based on the calibrated temperature of the object; and

- an offset-value calculator that calculates the offset value to be stored in the offset table, based on the temperature of the object estimated by the temperature estimator and the true temperature of the object.

10. The heat treatment apparatus according to claim 10, wherein the offset-value calculator has a function to calculate the true temperature of the object based on thickness of a film formed on the object.

11. A method of calibrating a temperature-detection system of a second heat treatment apparatus among a first and the second heat treatment apparatuses each having a processing vessel, a heater that heats an object to be processed, a thermal sensor and a temperature estimator that estimates a temperature of the object based on a detection signal from the thermal sensor, said method comprising:

(a) a temperature estimator adjusting process having the steps of: heating an object for temperature measurement placed in the processing vessel of the first heat treatment apparatus by the heater and measuring a true temperature of the object; and adjusting the temperature estimators of the first and second heat treatment apparatuses based on a result of the measurement of true temperature of the object;

(b) a first heat-treatment/film-thickness measuring process including: a first heat-treatment step of heat-treating a first object for heat-treatment arranged in the processing vessel of the first heat treatment apparatus having the temperature estimator, having been adjusted in the process (a), under a designated heat-treatment condition; and a first film-thickness measuring step of measuring a film-thickness of a film formed on the first object;

(c) a second heat-treatment/film-thickness measuring process including: a second heat-treatment step of heat-treating a second object for heat-treatment arranged in the processing vessel of the second heat treatment apparatus having the temperature estimator, having been adjusted in the process (a), under a designated heat-treatment condition; and a second film-thickness measuring step of measuring a film-thickness of a film formed on the second object; and

(d) an offset-value calculating process having the steps of: comparing the film-thickness of the first object measured in the first film-thickness measuring step with the film-thickness of the second object measured in the second film-thickness measuring step, and calculating an offset value for calibrating the temperature of the object estimated by the temperature estimator of the second heat treatment

apparatus based on the result of the comparison.

12. The calibration method according to claim 11, wherein the offset value is calculated based on a relationship between film-thickness and temperature in the offset-value calculating process.

13. The calibration method according to claim 11, further comprising:

(e) a third heat-treatment/film-thickness measuring process including: a third heat-treatment step of heat-treating a third object for heat-treatment arranged in the processing vessel of the second heat treatment apparatus while controlling a temperature using the offset value calculated in the offset-value calculating process; and a third film-thickness measuring step of measuring a film-thickness of a film formed on the third object; and

(f) a process of obtaining the relationship between film-thickness and temperature based on the film-thickness on the second object measured at the second film-thickness detecting step and the film-thickness on the third object detected at the third film-thickness detecting step.

14. The calibration method according to claim 11, wherein a plurality of first objects are arranged in the processing vessel in the first heat-treatment step; and, in the second heat-treatment step, a plurality of second heat-treatment objects are arranged at the same positions as the positions in which the first objects are arranged at the first heat-treatment step.

15. The calibration method according to claim 11, further comprising:

(e) third heat-treatment/film-thickness measuring process including: a third heat-treatment step of heat-treating the third object for heat-treatment, arranged in the processing vessel of the second heat treatment apparatus,

under the designated heat-treatment condition, while controlling a temperature using the offset value calculated in the offset-value calculating process; and a third film-thickness measuring step of measuring a film-thickness of a film formed on the third object;

(f) film-thickness comparing process of comparing the film-thickness on the third object measured at the third film-thickness measuring step with the film-thickness on the first object measured at the first film-thickness measuring step;

(g) offset-value re-calculating process including the steps of: calculating again the offset value, which is for calibrating the temperature of the object estimated by the temperature estimator of the second heat treatment apparatus, based on the comparison in the film-thickness comparing process, if a difference determined by the comparison between the film-thickness on the third object and the film-thickness on the first object is beyond a predetermined allowable range;

(h) process of repeating the processes (e), (f) and (g) until the difference between the film-thickness on the third object and the film-thickness on the first object becomes within the predetermined allowable range.

16. The calibration method according to claim 11, wherein:
in the process (a), a plurality of objects for temperature measurement are arranged in the processing vessel of the first heat treatment apparatus;

in the first heat-treatment step, a plurality of first objects are arranged at the same positions as positions where the objects for temperature measurement are arranged in the process (a), whereby films of generally equal film-thickness are formed on the first objects;

in the second heat-treatment step, the first objects are arranged at the same positions as positions where the objects for temperature measurement are arranged in the process (a); and

the offset value is calculated in the offset-value

calculating process (d) is that ensuring that respective film-thickness of the films formed on the objects for heat-treatment when they are heat-treated under the designated condition by the second apparatus are the substantially the same as respective film-thickness of the films on the first objects measured in the first film-thickness measuring step.

17. The calibration method according to claim 11, wherein in the temperature estimator adjusting process, the true temperature of the object for temperature measurement is measured by a thermoelectric couple attached to the object for temperature measurement.

18. A heat treatment system comprising:

a heat treatment apparatus having a processing vessel defining a processing chamber for processing an object to be processed therein, a heater that heats the object and a thermal sensor arranged in the processing chamber; and

a control device connected to the heat treatment apparatus, the control device having a temperature estimator that estimates a temperature of the object based on a detection signal of the thermal sensor, a temperature calibrator that corrects the temperature of the object estimated by the temperature estimator and a controller that controls an operation of the heater based on a calibrated temperature of the object corrected by the temperature calibrator.

19. The heat treatment system according to claim 18, wherein the heat treatment apparatus is detachably connected with the control device.

20. The heat treatment system according to claim 18, wherein the heat treatment apparatus is connected with the control device via a network.

21. The heat treatment system according to claim 18, wherein the control device further includes a register that records a periodical change of the temperature of the object.

22. The heat treatment system according to claim 18, further comprising a film-thickness measuring device which is connected to the control device to measure a thickness of a film formed on the object by a heat treatment carried out by the heat treatment apparatus.